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Different opinions of physicians on the importance of measures to prevent acquisition of *Pseudomonas aeruginosa* from the environment☆

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Abstract

Background: Since chronic infection with mucoid *Pseudomonas aeruginosa* (PA) is associated with deteriorating lung function, many parents of young children with cystic fibrosis (CF) fear the first PA positive throat swab as a milestone in the progression of the disease. To reduce the risk of PA acquisition from the environment, they perform preventive measures at home or outdoors. *Methods*: In an attempt to evaluate the attitude of CF physicians towards these measures and the respective consulting practice, we mailed a questionnaire to all 65 certified paediatric CF centres in Germany. *Results*: Physicians from 54 (83%) CF clinics replied. They expressed widely different ideas about the impact of the environment for the acquisition of *P. aeruginosa*, and recommended a large spectrum of preventive measures. Some physicians proposed only few precautions, which focussed on the prevention of cross-infection between patients, whereas others suggested prevention of any contact with moist or wet places, e.g. use different toothbrushes for mornings and evenings, or do without air-conditioning in the car. *Conclusions*: CF physicians have different opinions on the risk of PA acquisition from the environment. Doctors who recommend strict precautions could engender a parental fear of a ubiquous threat from invisible bacteria. The resulting extended safety measures might impair the family's quality of life.

Keywords: Environmental microbiology; Physician–patient relations; Cystic fibrosis; *Pseudomonas aeruginosa*

1. Introduction

Chronic infection with mucoid *Pseudomonas aeruginosa* in patients with cystic fibrosis is associated with deteriorating lung function and reduced survival [1,2]. The first isolates of these bacteria during the initial phase of colonisation usually resemble those in the environment [3]. They are of the non-mucoid morphotype, are more sensitive to antibiotics and easier to eradicate. Many CF clinics have, therefore, adopted a practice of early identification of *P. aeruginosa* colonisation, followed by immediate treatment with oral, inhaled or systemic antibiotics [4]. Since chronically infected CF patients have been identified as a potential source of *P. aeruginosa*, measures to prevent cross-infection between patients have been introduced in outpatient clinics, on the wards and during contact with other CF patients [5,6].

Parents of young children with cystic fibrosis, who are still free from *P. aeruginosa*, often fear the first positive sputum or throat swab as a milestone in the progression of the disease. Many families in Germany perform a range of specific measures in order to prevent or delay the acquisition of *P. aeruginosa*. Since the bacterium can be found in humid environments, children are not allowed to get into contact with potential sources of *P. aeruginosa*. According to the results of a recent interview study, the extent of these precautions varies between families [7,8].

The attitude of CF physicians towards the importance of acquisition of Pseudomonas from the environment has not been evaluated. When discussing with colleagues we found that different opinions exist on what parents should do to delay *P. aeruginosa* colonisation. There was general agreement that infection control measures

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to prevent cross-infection between patients are essential. Apart from this, however, some physicians were personally convinced that extended measures are useless, but they had difficulties to persuade the parents due to the lack of supporting scientific data. Other colleagues stated that they actively recommend a variety of different measures.

We designed the present study to evaluate the attitude of CF physicians in more detail. A questionnaire, which was mailed to each certified German paediatric CF centre should answer the following questions: which measures to prevent acquisition of *P. aeruginosa* do CF physicians recommend? How do physicians assess the importance of specific measures for the prevention of Pseudomonas acquisition? How heterogeneous is the spectrum of responses between different physicians?

2. Methods

2.1. Preceding pilot study

The items for the present questionnaire were derived from the results of a pilot study at Hannover Medical School, which was performed by one of the authors (G. U.). Parents of 21 CF children had been asked to assess potential hazards in the environment with respect to the risk of acquisition of *P. aeruginosa* [7]. Items extracted from these interviews, which were actually performed by families, e.g. 'The child is not the first to use the bathroom or WC in the morning', were used for the present study.

2.2. Questionnaire

The questionnaire had two parts: In the first part, we investigated the physicians' consulting practice with respect to potential hazards for the acquisition of PA from the environment. The physicians were asked to state which procedures they routinely recommend, and how they would respond to a question by parents whether one should perform a particular measure. Answers were given on a three-point scale: (1) the physician would actively recommend the practice as part of the routine information on *P. aeruginosa* infection; (2) the physician would accept the practice if parents suggested it; and (3) the physician would not endorse the practice if parents suggested it. In Part II of the questionnaire, we presented the same items, and asked the physicians how important they considered a certain practice for the prevention of *P. aeruginosa* acquisition. Answers were given on a four point scale: the practice was considered (1) definitely relevant; (2) probably relevant; (3) probably not relevant; and (4) irrelevant.

2.3. Participating centres

A questionnaire was mailed to each of the 65 paediatric cystic fibrosis outpatient clinics, which had been certified by the Structure Commission of the Mukoviszidose e.V., the German CF organisation, by 1999. All CF physicians were asked to participate. The survey was not anonymous, since the centre number was reported on the form.

2.4. Statistics

Data were analysed using the SPSS 6.1.3. software package for statistical analysis (SPSS Inc., Chicago, Illinois, USA). The items were grouped into the following categories: patient to patient contact, sanitary hygiene, oral hygiene, indoor measures, outdoor measures, CF treatment and miscellaneous. Descriptive statistics for items and for categories were calculated. Summary scores were computed for each physician for 'consulting practice' and for 'relevance'. This was done by adding up the answers to all 34 questions and calculating the percentage level in relation to the maximum possible score. A score of 100% indicates that the physician had actively recommended all practices (part 1), or that he/she had regarded all items as definitely relevant (part 2). Scores of 0% would mean that the physician had assessed all measures as irrelevant, or that he/she had discouraged all measures.

3. Results

Of the 65 certified outpatient clinics invited to participate, 54 (83%) responded to the questionnaire. A total of 61 questionnaires were returned, since five clinics sent in responses from two or more physicians. The Table 1 shows the answers to each of the 39 items. A minority of questions were answered unanimously, whereas for most items a wide spectrum of responses was given.

Most physicians regarded it 'definitely relevant' to clean the inhaler after every application (87%), to observe particular rules in the company of other CF patients (80%), to ensure an optimal nutritional status (71%), and to pay attention to intensive physiotherapy and sports (64%). Items that were regarded as 'irrelevant' by the majority of physicians were: do without dental checkups (55%), not to take part in school trips (53%) and not to jump into puddles (53%). Apart from these practices, considerable uncertainty was observed between physicians, since a large number of items were regarded as either 'probably relevant' or 'possibly not relevant'.

Regarding consulting practice, most physicians stated that they 'actively recommended' influenza vaccination (96%), to clean the inhaler (95%), to ensure an optimal

Table 1
Responses to the questionnaire

Item No.		Consulting practice			Importance for prevention of PA acquisition			
		Actively recommended	Accepted	Not advised/ discouraged	Definately relevant	Probably relevant	Probably not relevant	Irrelevant
	Sanitary hygiene							
SH 4#	The child should always close the toilet lid before flushing	60.0	29.1	7.3*	25.5	45.5	18.2	10.9*
SH 2#	The child is not the first to use the bathroom or WC in the morning	50.9	32.7	16.4	25.5	40.0	23.6	10.9
SH 6§	Alternating use of several flannels to ensure that they dry out before use	18.2	54.5	23.6	5.5	36.4	29.1	25.5
SH 7§	Cleaning of all washbasins and toilets in the kindergarten every morning	18.2	41.8	34.5	9.1	34.5	29.1	25.5
SH 5§	Use of different toothbrushes for mornings and evenings	10.9	54.5	30.9	9.1	21.8	45.5	23.6
SH 3§	The child does not flush the toilet him/herself	7.3	32.7	58.2	5.5	16.4	45.5	30.9
SH 1	Disinfection of kitchen and bathroom in addition to normal cleaning	3.6	36.4	58.2	1.8	7.3	63.8	29.1
	Oral hygiene							
OH 4	The child is taught that under no circumstances should objects (e.g., recorders, balloons and other objects which come into contact with the mouth) belonging to other children be put into the mouth	29.1	45.5	21.8	20.0	23.6	38.2	16.4
OH 5	The child is taught that under no circumstances should he/she drink from a glass or cup belonging to another child	29.1	40.0	25.5	16.4	25.5	40.0	16.4
OH 2§	Do not drink tap water unless it has been boiled	20.0	32.7	47.3	5.5	20.0	38.2	36.4
OH 1	The child is not given drinks from bottles which have been open for half a day or longer	14.5	52.7	30.9	5.5	27.3	47.3	20.0
OH 3§	Glasses are not used a second time but are washed up immediately	9.1	56.4	30.9	7.3	18.2	47.3	27.3
	Indoor measures							
Ind 5	Remove the humidifiers from the radiators	67.3	30.9	1.8	41.8	41.8	14.5	1.8
Ind 1#	Remove pot plants from the child's room	60.0	25.5	14.5	32.7	40.0	18.2	9.1
Ind 3#	Remove the aquarium from the child's room	47.3	41.8	7.3	25.5	49.1	14.5	10.9
Ind 2	Remove pot plants from the flat	12.7	45.5	40.0	1.8	38.2	32.7	27.3
Ind 4	Remove the aquarium from the flat	12.7	56.4	29.1	7.3	34.5	34.5	23.6
Ind 6§	Do without air conditioning in the car	9.1	50.9	38.2	7.3	34.5	34.5	23.6
	Outdoor measures							
Outd 5	Do not use whirlpools	60.0	27.3	12.7	29.1	47.3	16.4	5.5
Outd 6§	Do not visit a sauna	18.2	30.9	47.3	3.6	30.9	43.6	21.8
Outd 1	Avoid bathing in gravel pits and standing water	12.7	50.9	32.7	5.5	38.2	36.4	20.0
Outd 2	Avoid the use of public showers	9.1	36.4	54.5	3.6	34.5	43.6	18.2
Outd 7	The child should not jump into or splash about in puddles	5.5	16.4	76.4	1.8	18.2	25.5	52.7
Outd 4	Do not visit indoor swimming pools	1.8	18.2	78.2	1.8	16.4	43.6	38.2
Outd 3	Do not visit open air swimming pools	0	10.9	89.1	0	7.3	52.7	40.0
	Patient-to-Patient contact							
Pat 1	Observe particular rules in the company of other CF patients (don't cough over others or sleep in the same room)	90.9	9.1	0	80.0	12.7	3.6	0

Table 1 *(Continued)*

Item No.		Consulting practice			Importance for prevention of PA acquisition			
		Actively recommended	Accepted	Not advised/ discouraged	Definately relevant	Probably relevant	Probably not relevant	Irrelevant
Pat 3	Do not stay at a health resort	10.9	25.5	58.2	9.1	29.1	25.5	34.5
Pat 2	Avoid contact with other CF patients as a matter of principle	7.3	21.8	65.5	14.5	40.0	29.1	16.4
	CF treatment							
Treat 7	Influenza vaccination	96.4	3.6	0	49.1	34.5	10.9	3.6
Treat 1	Clean and dry the inhaler after every application	94.5	1.8	3.6	87.3	9.1	3.6	0
Treat 4	Ensure an optimal nutritional status	94.5	5.5	0	70.9	18.2	7.3	1.8
Treat 3	Pay particular attention to intensive physiotherapy and/or sport	90.9	9.1	0	63.6	20.0	10.9	3.6
Treat 5	Early antibiotic treatment of respiratory tract infections	87.3	5.5	3.6	49.1	32.7	10.9	1.8
Treat 6	Rigorous hygienic measures with virus infections in the family	43.6	47.3	7.3	27.3	36.4	25.5	7.3
Treat 2	Disinfect the inhaler after every application	18.2	29.1	49.1	14.5	18.2	47.3	20.0
Dent 1#	Draw the attention of the dentist to the Pseudomonas problem	61.8	32.7	3.6	43.6	38.2	10.9	7.3
Dent 2	When possible do without dental check-ups	0	5.5	90.9	1.8	10.9	32.7	54.5
Homo	Use homeopathic products or those from complementary medicine to enhance the immune system	0	76.4	23.6	0	18.2	34.5	45.5
Scho	The child does not take part in school trips because the rules are not so strictly adhered to as at home	0	3.6	96.4	1.8	5.5	40.0	52.7

*missing values (between 0 and 6% per item) are the reason why figures do not add up to 100%.

and § refer to significant differences between the upper and lower quartiles of physicians when they were grouped according to the respective summary scores (see text).

'definitely' or 'probably relevant' vs. 'probably not relevant'.

§ 'probably relevant' vs. 'irrelevant'.

nutritional status (95%), to pay attention to intensive physiotherapy (91%), to observe particular rules in the company of other CF patients (91%), and to treat respiratory tract infections early and vigorously with antibiotics (87%). Many respondents 'actively recommended' to remove humidifiers from the radiators (67%), to draw the attention of the dentist to the Pseudomonas problem (62%), not to use whirlpools (60%), to close the toilet lid before flushing (60%) and to remove pot plants from the child's room (60%). When parents asked whether they should perform a particular measure to protect their child from getting *P. aeruginosa*, the majority of physicians 'did not endorse' the following items: the child does not take part in school trips, when possible do without dental checkups, do not visit indoor or open air swimming pools, the child should not jump into or splash about in puddles, avoid contact with other CF patients as a matter of principle, do not stay at a health resort, the child does not flush the toilet him/herself, disinfection of kitchen and bathroom in addition to normal cleaning and avoidance of public showers.

Controversy was observed regarding four particular items: the child is taught that under no circumstances should objects belonging to other children be put into the mouth, the child is taught that he/she should not drink from a glass or cup belonging to another child, cleaning of all wash basins and toilets in the kindergarten every morning, alternating use of several flannels to ensure that they dry out before use.

The classification of items into different groups such as 'indoor measures' or 'patient to patient contact' (Table 1) was supported statistically, since Cronbach's alpha was between 0.70 and 0.85. When means and 95% confidence intervals were calculated for each category, 'CF treatment' and 'patient to patient contact' had the highest scores for importance, and 'oral hygiene' and 'outdoor measures' had the lowest.

In further analysis, summary scores for 'consulting practice' and 'importance' were calculated for each physician. As shown in Fig. 1, there was a significant linear correlation between the reported consulting practice and the physician's assessment of the importance of a specific measure. The graph also shows the wide

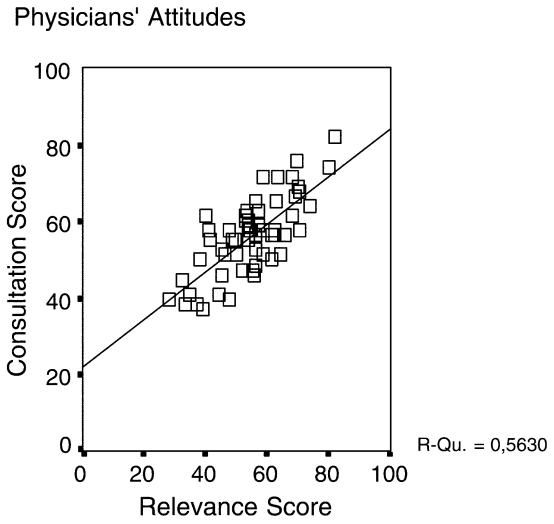

Fig. 1. Summary scores for 'consulting practice' and 'importance' were calculated for each physician by adding up the answers to the questions and calculating the percentage level in relation to the maximum possible score. A score of 100% would indicate that the physician had actively recommended all practices (Consulting Practice), or that he/she had regarded all items as definitely relevant (Importance). Scores of 0% would mean that the physician had assessed all measures as irrelevant, or that he/she had deterred all measures. CF physicians differed considerably in their opinions. A significant linear correlation ($R^2 = 0.56$) was observed between the reported consulting practice and the physician's opinion on the importance of a specific measure.

range of opinions between the CF physicians. The scores for 'consulting practice' were between 37 and 82% and those for 'importance' between 28% and 82%, respectively.

We compared the physicians who belonged to the highest and to the lowest quartile for 'importance' scores with each other, and looked for substantial differences in responses between these groups. Physicians with the highest scores regarded the following items as 'probably relevant', in contrast to the lowest quartile of physicians, who assessed them as 'irrelevant': do not visit a sauna, the child does not flush the toilet himself, use of different toothbrushes for mornings and evenings, alternating use of several flannels, cleaning of all wash basins and toilets of the kindergarten every morning, do not drink tap water unless it has been boiled, glasses are not used a second time but are washed up immediately, do without air-conditioning in the car.

We then used five different items to define a physician as 'bacterium-focused': disinfection of kitchen and bathroom in addition to normal cleaning, do not drink tap water unless it has been boiled, the child is not given drinks from bottles which have been opened for half a day, glasses are not used a second time but are washed up immediately, and the child should not jump into or splash about in puddles. These items were regarded by the authors as indicating a bacterium-focused view. Thirty-two physicians (52%) did not regard any of these items as definitely or probably relevant. Nine doctors assessed one item, 12 doctors two items, three physicians three, three physicians four and two physicians five items as 'probably' or 'definitely relevant'.

4. Discussion

The results of the present survey indicate that many CF physicians in Germany regarded specific sites in the environment as important sources for *P. aeruginosa* acquisition. In order to prevent children from early infection with this bacterium, they recommended specific measures to perform at home, in the kindergarten, at school and when playing outdoors. For example, children should use different toothbrushes for mornings and evenings, they should not drink tap water unless it had been boiled, they should not use public showers, parents should do without air-conditioning in the car, and they should draw the attention of the dentist to the Pseudomonas problem. These examples reflect the idea that getting into contact with humid environments may be hazardous for CF children not yet colonised with *P. aeruginosa*.

The results of our study correspond to advice given by German CF experts in a recent publication [8]. This book, which was initiated by the German CF foundation, contains practical recommendations on how to prevent lung infections in children with CF. Five different chapters on topics such as 'in the family', 'in the hospital', 'on vacation', 'at the dentist's', 'in pools, lakes and at the seaside', summarise precautions, which should be followed by parents and children. In addition, suggestions and rules are presented which should be observed in the company of other CF patients. This book was published after the present survey had been finished, so that the respective recommendations had no influence on the physicians' responses.

Cross-infections with *P. aeruginosa* between CF patients in the hospital, in summer camps and in rehabilitation units have been described in the literature by many authors [9–13]. Sputum of patients with cystic fibrosis may contain high concentrations of *P. aeruginosa*, such as 10^8 colony forming units per millilitre [14]. Bacteria also have been detected on the hands of both patients and medical personnel [15]. As a consequence, recommendations on how to limit cross-infection between CF patients have been established, e.g. segregation of patients in the wards [16,17]. International guidelines explain precautions, which should be followed when meeting other CF patients and particularly when attending CF congresses [18]. These rules might have been influenced by data on cross-infection with *Burkholderia cepacia*, a bacterium which may cause life threatening infections even in relatively healthy persons with CF [19,20].

The role of the environment for the acquisition of *P. aeruginosa* has not been extensively discussed in the literature. We are not aware of publications from other countries describing detailed precautions in the surroundings of the child, which would be comparable to those investigated in the present survey. The UK Cystic Fibrosis Trust has recently published a booklet with suggestions for prevention and control of *P. aeruginosa* [16]. Littlewood and co-authors have thoroughly reviewed the available literature using a grading scheme for the type of evidence. In the chapter on 'General environmental sources', only hydrotherapy pools and jacuzzis were regarded a risk for people with CF, whereas showers and swimming pools were assessed as generally safe (provided chlorination is maintained). The UK physicians did not mention any of the precautions from our survey on sanitary hygiene, oral hygiene or indoor sites. The authors focussed on the importance of microbiological surveillance and early treatment, instead of making suggestions how parents could prevent the acquisition of bacteria from the home environment. When *P. aeruginosa* is detected for the first time, eradication should be attempted, for example with nebulized colistin and oral ciprofloxacin. Using these principles, physicians in the Leeds CF clinic have achieved a substantial reduction in the proportion of chronically infected children and adolescents from 24 to 4% during the last 10 years [21]. These results confirmed the experiences of the Copenhagen group, who had been the first to report the positive outcome of a strict policy with patient segregation and early aggressive treatment [6,22]. A comparable practice has also been adopted by most German CF centres, as stated by the physicians responding to the present survey (data not shown). Furthermore, two recent studies suggested that the chronic prophylactic administration of anti-stapyloccocal antibiotics in young children with CF might be a iatrogenic risk factor for early colonisation with *P. aeruginosa* [23,24]. In contrast to the situation two decades ago, physicians can nowadays help to postpone the chronic stage of infection with mucoid *P. aeruginosa*. We, therefore, regard early detection and efficient therapy of bacterial colonisation as more important than extended preventive measures practiced by the family over many years.

We realize that it will be almost impossible to establish scientifically valid data on which measures are advisable and which are superfluous. Even if most precautions described in our survey are not supported by evidence from the literature, one could argue that following these rules would cause no harm. It should be easy for parents and children to adopt these safety measures, and the family would benefit from the sense of being in control. However, side effects of performing extended measures are not uncommon [26]. The previous interview study showed that parents who performed extended safety measures regarded every moist or wet site in the surrounding as a potential source of PA infection, which could be followed by a subsequent decline of the child's health. If infection with *P. aeruginosa* eventually occurred, these parents typically felt responsible and guilty of not having appropriately protected their child from the bacteria. Physicians consulting parents should, therefore, not overlook possible adverse effects of suggesting extended preventive measures.

When discussing the consequences of recommendations on *P. aeruginosa* prevention, another aspect deserves consideration, which we call a 'paradoxical message'. After the CF diagnosis has been established, parents are usually told that although CF is a serious disease, children should grow up as normal as possible, and should not be prevented from sharing activities with their peers. And in fact most families manage to live a comparably normal life in spite of the burden of treatment [25]. To introduce measures of questionable effectiveness against an ubiquitous bacterium would contradict this message of normality. This could trigger additional parental precautions, which might further impair the family's quality of life. One father in our interview study commented on the risks of taking precautions too strictly: 'Your daughter would become so frustrated with her disease that much more serious problems would arise than those caused by Pseudomonas infection'. Furthermore, many measures erroneously suggest that the mere contact with the bacterium will immediately lead to infection. This was in fact the predominant conviction among the parents in our interview study [7,26]. Given the ubiquitous nature of *P. aeruginosa*, this belief could trigger pervading fears of acquisition in spite of practising numerous precautions. One mother gave the following perturbing statement: 'I can certainly cope with CF as such, but this germ makes it really difficult to live a normal life'.

In summary, the present survey which included more than 80% of German paediatric CF centres revealed that physicians have different concepts regarding the influence of the environment for acquisition of *P. aeruginosa*. A large spectrum of preventive measures was reported. Some physicians recommended only few precautions, focussing on the prevention of cross-infection between patients, whereas others suggested to perform a range of different measures to prevent the contact with moist or wet places at home or outdoors. Considering the reasons why physicians recommended many precautions, the positive aspects of risk prevention, i.e., the feeling of being in control, should be weighed against possible adverse effects on parents and children, such as permanent anxiety or feeling guilty if colonisation occurs. A larger multicentre study is currently under way to further investigate the impact of such recommendations on the

families' daily lives and to identify possible adverse effects.

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